greater WELLINGTON
REGIONAL COUNCIL

Annual coastal monitoring report for the Wellington region, 2007/08

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1. Introduction

Greater Wellington Regional Council (Greater Wellington) has a responsibility to manage and monitor the Wellington region's near-shore coastal environment; the area extending from mean high water springs to 12 nautical miles offshore. This near-shore environment contains significant habitats for a wide variety of plants and animals, and also provides for a diverse range of human activities and values.

Greater Wellington's Environmental Monitoring and Investigations Department oversees monitoring and investigations of water quality and ecosystem health in the Wellington region's near-shore coastal environment. This report summarises the results of such monitoring and investigations undertaken and/or reported over the period 1 June 2007 to 30 June 2008.

2. Overview of coastal monitoring programme

2.1 Background

Coastal monitoring in the Wellington region began over 20 years ago, with a focus on microbiological water quality, reflecting the high usage of much of the region's coastline for contact recreation such as swimming and surfing. Periodic assessments of contaminants in shellfish flesh commenced around 1997, with the most recent assessment undertaken at 20 sites in 2006 (see Milne 2006). In 2004 monitoring expanded into coastal ecology and sediment quality, with a key focus being the effects of urban stormwater on our coastal harbour environments. In addition, over 2004-2008 broad-scale surveys of the region's coastal habitats were undertaken, with fine-scale sediment and ecological assessments undertaken at representative locations of selected estuaries and sandy beaches. The information gained from these studies was recently combined with ecological vulnerability assessments to identify priorities for a long-term monitoring programme that will enable Greater Wellington to fulfil state of the environment monitoring obligations with respect to coastal ecosystems.

2.2 Monitoring objectives

The aims of Greater Wellington's coastal monitoring programme are to:

1. Assist in the detection of spatial and temporal changes in near-shore coastal waters;
2. Contribute to our understanding of coastal biodiversity in the region;
3. Determine the suitability of coastal waters for designated uses;
4. Provide information to assist in targeted investigations where remediation or mitigation of poor water quality is desired; and
5. Provide a mechanism to determine the effectiveness of policies and plans.

Note: the suitability of coastal waters for contact recreation purposes is assessed separately under Greater Wellington's recreational water quality monitoring programme (see Ryan & Warr 2008).

2.3 Monitoring sites and variables

Coastal monitoring and investigations undertaken and/or reported over the period 1 June 2007 to 30 June 2008 are summarised in Sections 3 to 8. They included:

- microbiological water quality monitoring (77 sites across the region);
- an investigation of sediment quality in Wellington Harbour (17 sites);
- an ecological vulnerability assessment of Lake Onoke;
- broad-scale habitat mapping and fine-scale ecological monitoring of intertidal areas in Porirua Harbour (4 fine-scale sites);

- fine-scale ecological monitoring of Whareama Estuary (2 sites); and
- fine-scale ecological monitoring of Castlepoint Beach (2 sites).

3. Microbiological water quality monitoring

3.1 Introduction

Microbiological water quality was monitored at 77 coastal sites across the Wellington region over 2007/08 (Figure 3.1, Appendix 1), as follows:

- Kapiti Coast District – 20 sites
- Porirua City – 15 sites
- Hutt City – 15 sites
- Wellington City – 22 sites
- Wairarapa – 5 sites

Monitoring was a joint effort involving Greater Wellington, Kapiti Coast District Council, Porirua City Council, Hutt City Council, and Wellington City Council. The sites monitored reflect their use by the public for contact recreation; in particular, swimming, surfing, and boating. This year, for the first time, water quality monitoring was carried out in the Pauatahanui Inlet at Paremata Bridge, bringing the number of sites in Porirua City to 15.

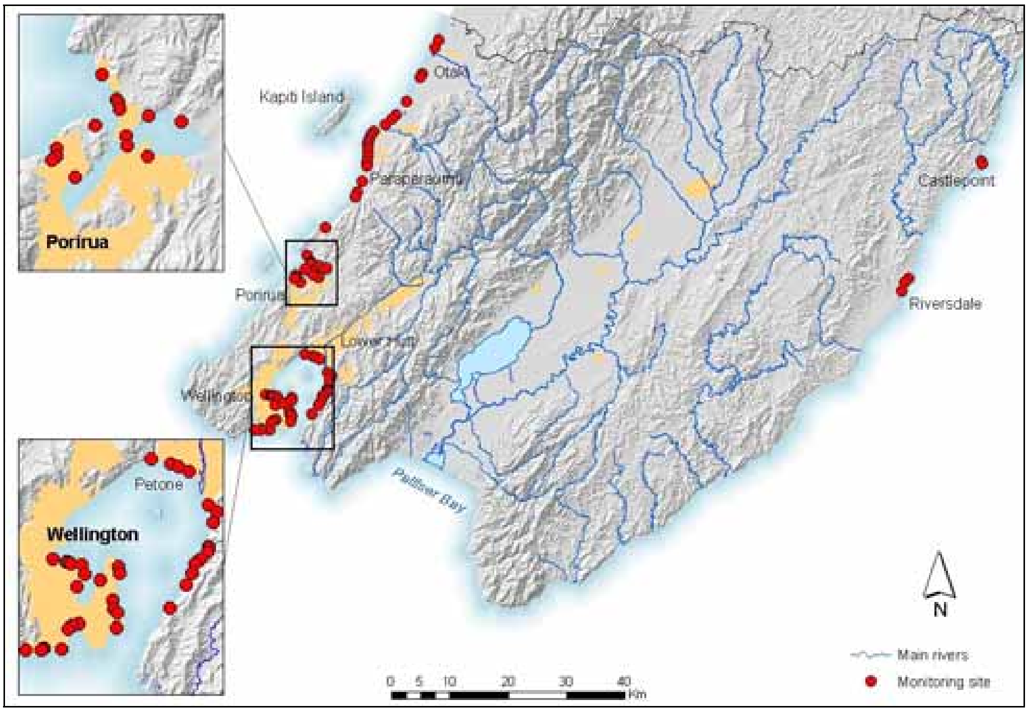

Figure 3.1: Coastal water quality sites monitored over 2007/08

3.2 Monitoring protocol

Sites were sampled weekly during the summer bathing season (1 November to 31 March inclusive) as part of Greater Wellington's recreational water quality monitoring programme (refer Ryan & Warr 2008), and at least monthly during the remainder of the year[1]. On each sampling occasion a single water sample

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[1] Camp Bay (Hutt City), Breaker Bay (Wellington City), Princess Bay (Wellington City) and Riversdale Beach South (Wairarapa) were sampled fortnightly during the summer months (refer Ryan & Warr 2008).

was collected 0.2 metres below the surface in 0.5 metres water depth and analysed for enterococci indicator bacteria using a membrane filtration method. In addition, water samples from six sites popular for recreational shellfish gathering, and three sites in Porirua Harbour, were tested for faecal coliform indicator bacteria (Appendix 1).

Observations of weather and the state of the tide, and visual estimates of seaweed cover, were made at each site to assist with the interpretation of the monitoring results. For example:

- Rainfall may increase enterococci counts by flushing accumulated debris from urban and agricultural areas into coastal waters.
- Wind direction can influence the movement of currents along the coastline and can therefore affect water quality at a particular site.
- In some cases, an increase in enterococci counts may be due to the presence of seaweed. Under warm conditions when seaweed is excessively photosynthesising or decaying, enterococci may feed off the increased carbonaceous material produced during photosynthesis or off the decaying seaweed.

An estimate of the daily rainfall in the catchment adjoining each site over the bathing season was made by obtaining records from the nearest rain gauge.

A list of field and laboratory methods can be found in Ryan & Warr (2008).

3.3 Results

The results of microbiological water quality testing undertaken during the official summer bathing season are discussed in detail in *On the Beaches 2007/08: Annual recreational water quality monitoring report for the Wellington region* (Ryan & Warr 2008). Tables 3.1 and 3.2 summarise the median, 95th percentile and maximum enterococci and faecal bacteria counts recorded from all sampling conducted during the period 1 July 2007 to 30 June 2008 for each of the 77 marine sites (i.e., these statistics include the results of additional follow-up sampling conducted in response to an exceedance of the Ministry for the Environment/Ministry of Health (2003) microbiological water quality guidelines). In the majority of instances, elevated indicator bacteria counts coincided with rainfall.

The highest enterococci counts were recorded at Scorching Bay (19,000 cfu/100 mL), Kio Bay (17,000 cfu/100 mL) and Oriental Bay (12,000 cfu/100 mL at the Band Rotunda) on 10 June 2008; counts of this magnitude at these sites are surprising given there had only been 6-14 mm of rainfall in the 72 hours prior to sampling[2]. Investigations by Wellington Water Management (on behalf of Wellington City Council) did not find any obvious cause for the elevated results (e.g., sewer overflows). Follow-up samples were taken the next day and returned very low enterococci counts (27, 4 and <4 cfu/100 mL respectively).

[2] 6 mm of rainfall was recorded at Pencarrow Lakes and 14 mm of rainfall was recorded at Karori Reservoir.

Table 3.1: Summary of enterococci counts recorded at 77 coastal sites monitored over 1 July 2007 to 30 June 2008 inclusive

Bathing Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach @ Surf Club	29	3	70	330
Otaki Beach @ Rangiuru Rd	29	3	36	270
Te Horo Beach S of Mangaone Strm	30	28	241	1,480
Te Horo Beach @ Kitchener St	29	5	48	570
Peka Peka Beach @ Rd End	29	3	75	185
Waikanae Beach @ William St	29	7	65	190
Waikanae Beach @ Tutere St T.C.	23	6	79	270
Waikanae Beach @ Ara Kuaka C.P.	29	8	79	590
Paraparaumu Beach @ Ngapotiki St	30	11	199	585
Paraparaumu Beach @ Nathan Ave	30	20	313	520
Paraparaumu Beach @ Maclean Pk	30	22	167	240
Paraparaumu Beach @ Toru Rd	28	15	137	140
Paraparaumu Beach @ Wharemauku Rd	30	20	185	4,400
Raumati Beach @ Tainui St	30	17	160	355
Raumati Beach @ Marine Gardens	30	10	250	450
Raumati Beach @ Aotea Rd	30	11	130	435
Raumati Beach @ Hydes Rd	30	10	145	210
Paekakariki Beach @ Whareroa Rd	28	4	70	90
Paekakariki Beach @ Surf Club	28	5	38	115
Paekakariki Beach @ Memorial Hall	28	4	28	45
Porirua				
Pukerua Bay	29	4	56	600
Karehana Bay @ Cluny Rd	29	8	102	170
Plimmerton Beach @ Bath St	30	6	140	220
Plimmerton Beach @ Queens Ave	29	8	126	230
South Beach @ Plimmerton	29	8	110	490
Paremata Beach @ Pascoe Ave	29	2	46	490
Pauatahanui Inlet @ Water Ski Club	28	6	58	120
Pauatahanui Inlet @ Motukaraka Pt	29	2	48	200
Pauatahanui Inlet @ Browns Bay	29	4	96	1,500
Pauatahanui Inlet @ Paremata Bridge	29	4	40	410
Porirua Harbour @ Rowing Club	35	40	3,250	9,600
Titahi Bay @ Bay Drive	31	12	280	940
Titahi Bay at Toms Rd	33	12	306	1,000
Titahi Bay @ South Beach Access Rd	34	34	208	440
Onehunga Bay	28	4	35	130
Hutt				
Petone Beach @ Water Ski Club	31	4	265	430
Petone Beach @ Sydney St	31	8	445	2,100
Petone Beach @ Settlers Museum	30	8	255	960
Petone Beach @ Kiosk	31	8	530	1,000

Table 3.1 *cont*.: Summary of enterococci counts recorded at 77 coastal sites monitored over 1 July 2007 to 30 June 2008 inclusive

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95^{th} percentile	Max
Hutt				
Sorrento Bay	29	4	95	840
Lowry Bay @ Cheviot Rd	33	4	622	2,000
York Bay	32	2	723	1,000
Days Bay @ Wellesley College	31	4	365	1,400
Days Bay @ Wharf	31	4	445	1,200
Days Bay @ Moana Rd	29	2	52	960
Rona Bay @ N end of Cliff Bishop Pk	29	12	104	1,200
Rona Bay @ Wharf	31	12	350	1,300
Robinson Bay @ HW Shortt Rec Grd	32	8	276	1,000
Robinson Bay @ Nikau St	31	12	1,350	1,800
Camp Bay	18	2	36	84
Wellington City				
Aotea Lagoon	32	4	551	880
Oriental Bay @ Freyberg Beach	30	3	833	1,700
Oriental Bay @ Wishing Well	33	8	652	1,600
Oriental Bay @ Band Rotunda	33	4	988	12,000
Balaena Bay	29	2	110	390
Kio Bay	30	2	186	17,000
Hataitai Beach	29	2	94	160
Shark Bay	28	2	81	96
Mahanga Bay	28	3	42	88
Scorching Bay	30	2	168	19,000
Worser Bay	28	2	38	120
Seatoun Beach @ Wharf	30	4	412	1,800
Seatoun Beach @ Inglis St	30	4	95	330
Breaker Bay	18	2	45	120
Lyall Bay @ Tirangi Rd	30	6	267	940
Lyall Bay @ Onepu Rd	28	4	44	76
Lyall Bay @ Queens Drive	28	2	28	110
Princess Bay	19	2	310	2,600
Island Bay @ Surf Club	32	6	538	1400
Island Bay @ Reef St Recreation Grd	31	12	1,450	2,200
Island Bay @ Derwent St	26	2	59	170
Owhiro Bay	35	16	684	2,300
Wairarapa				
Castlepoint Beach @ Castlepoint Strm	27	2	18	20
Castlepoint Beach @ Smelly Creek	27	2	15	20
Riversdale Beach @ Lagoon Mouth	27	2	15	1,100
Riversdale Beach Between the Flags	27	2	4	8
Riversdale Beach South	17	2	5	8

Table 3.2: Summary of faecal coliform counts recorded at nine coastal sites monitored over 1 July 2007 to 30 June 2008 inclusive

Site	Total no. of samples	Faecal coliforms (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach @ Surf Club	29	9	429	575
Peka Peka Beach @ Rd End	29	6	202	237
Raumati Beach @ Hydes Rd	30	13	315	395
Hutt				
Pauatahanui Inlet @ Browns Bay	29	4	346	620
Pauatahanui Inlet @ Motukaraka Point	29	2	72	450
Porirua Harbour @ Rowing Club	32	44	1,272	6,400
Hutt				
Sorrento Bay	29	2	42	600
Wellington City				
Shark Bay	28	2	39	120
Mahanga Bay	28	3	27	88

4. Wellington Harbour sediment quality investigation

The Wellington Harbour marine sediment quality investigation commenced in 2006/07. Sample analysis and reporting were completed in 2007/08. This section is a summary of the completed investigation reported by Stephenson et al. (2008).

4.1 Background

Like other coastal environments surrounded by densely populated areas, Wellington Harbour receives significant stormwater inputs with the potential to adversely impact on the health of its ecosystems (Figure 4.1). The most significant medium to long-term impact of urban stormwater discharges on the Wellington Harbour environment is likely to be the accumulation of stormwater-related contaminants in the sediments. This is because the contaminants can, over time, build up to concentrations that are toxic to benthic (sediment-dwelling) organisms. Benthic organisms are a major component of harbour and coastal ecosystems; they provide food for fish and other organisms, affect nutrient cycling and contribute significantly to marine productivity.

The Wellington Harbour marine sediment quality investigation was partially funded by Wellington City Council and Hutt City Council and follows earlier assessments of sediment quality in the Porirua Harbour (Williamson et al. 2005; Stephenson & Mills 2006). The investigation links in with Greater Wellington's study of chemical contaminants in stormwater systems and the effects of urban stormwater discharges on aquatic receiving environments in the Wellington region.

Figure 4.1: Wellington Harbour from the suburb of Brooklyn

4.1.1 Aims of the investigation

The primary aims of the investigation were:

1. To make an assessment of the Wellington Harbour receiving environment in terms of sediment quality and benthic community health to provide a sound scientific basis for any management response in relation to urban stormwater discharges; and

2. To select the monitoring sites that might be used to detect changes in sediment quality and benthic community health over time, thereby allowing the ongoing evaluation of urban stormwater management actions directed at maintaining or enhancing the Wellington Harbour receiving environment.

4.2 Sampling sites, methods and variables

Seventeen sub-tidal sites were sampled in Wellington Harbour over October-November 2006 (Figure 4.2 & Table A2.1, Appendix 2). The 17 sites selected provided good spatial coverage, making this investigation the most comprehensive assessment of surface sediment quality in the harbour since that undertaken by Stoffers et al. (1986). Although selected to assess the impacts of stormwater discharges, the sites investigated only target *far-field* effects rather than effects in areas close to the discharge points, reflecting Greater Wellington's focus on the health of the wider harbour environment.

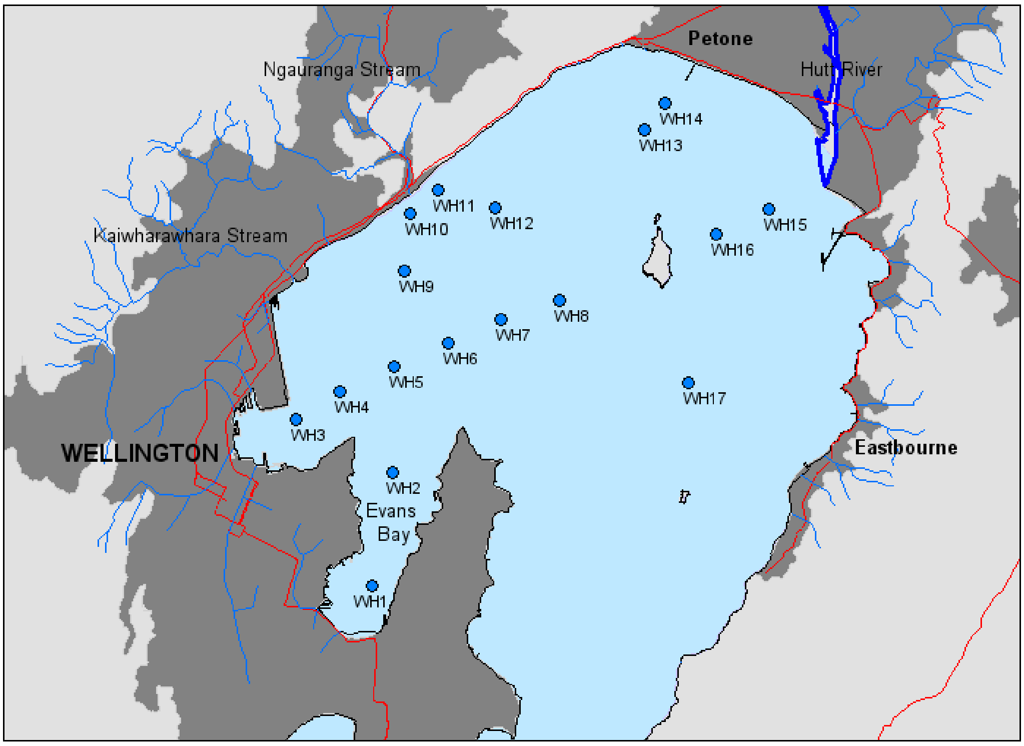


Figure 4.2: Map of Wellington Harbour showing the 17 sampling locations

Samples were collected by the use of a boat, GPS and scuba divers using similar protocol to recent surveys of contaminants in Porirua Harbour sediments (Williamson et al. 2005, Stephenson & Mills 2006).

4.2.1 Sediments

At each site 25 sediment core samples were collected from a sampling area 20 m in diameter, with samples randomly assigned into five replicate groups for analysis (top 30 mm). Samples were tested for:

- particle size distribution;
- total organic carbon (TOC);
- weak acid-extractable and total heavy metals;
- polycyclic aromatic hydrocarbons (PAHs);
- organochlorine pesticides (e.g., DDT); and
- organotin (marine antifouling) compounds.

Both the ANZECC (2000) Interim Sediment Quality Guidelines (ISQG) and the Auckland Regional Council's (2004) Environmental Response Criteria (ERC) were used to assess the sediment chemistry results. These guidelines are not "pass or fail" numbers; they are set at the concentrations which experimental and/or field evidence suggests are likely to result in impacts on aquatic life. Both the ANZECC and ERC guidelines have "low" (effectively alert) and "high" values[3]; exceedances of these "low" and "high" values are indicated by orange and red colouring respectively in the graphs in Section 4.3.

4.2.2 Benthic ecology

Eight "benthos" sediment core samples were collected from an area adjacent to each sediment sampling site. Processing of the samples included:

- identification (to the lowest taxonomic level practicable) and enumeration of benthic fauna;
- measurement of shell lengths of selected species (e.g., bivalve molluscs); and
- selection and labelling of specimens for a reference collection.

4.3 Results and discussion

4.3.1 Sediment quality

Concentrations of lead, mercury, and to a lesser extent copper and zinc (Figure 4.3), are present above sediment quality guidelines in the subtidal sediments of various parts of Wellington Harbour, especially those adjacent to Wellington City. Tributyltin (TBT) is only present above sediment quality guidelines at the entrance to the Lambton Basin and off Ngauranga, but its less toxic breakdown product dibutyltin is widespread. High molecular weight PAH compounds are above sediment quality guidelines in Evans Bay, and at the entrance to the Lambton Basin (Figure 4.4).

[3] These two sets of guidelines differ with respect to how they were derived and how they are interpreted– see Stephenson et al. (2008) for details.

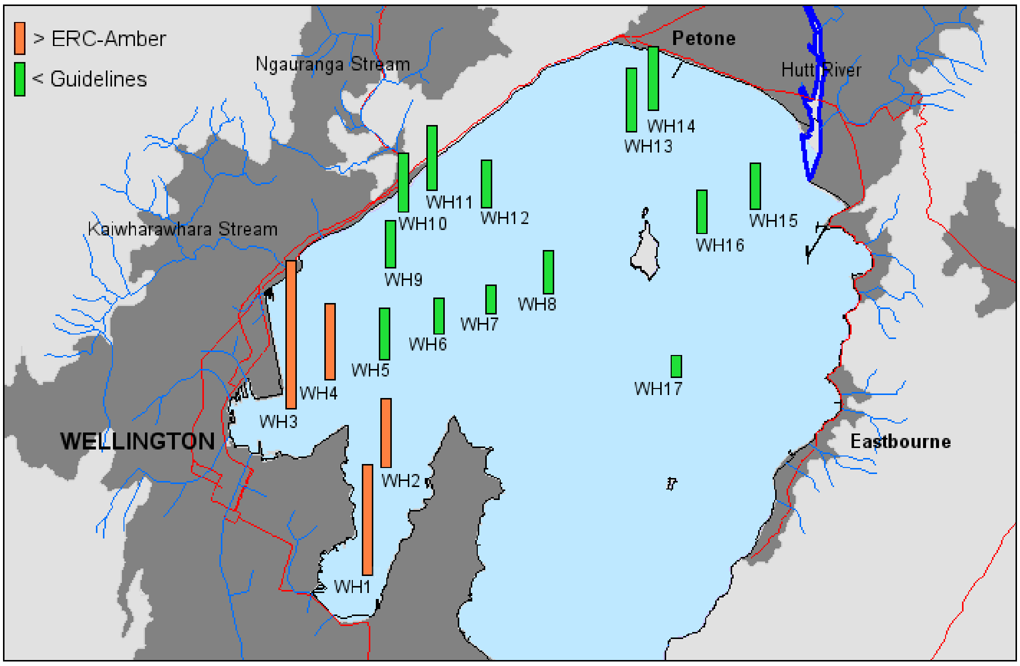


Figure 4.3: Relative concentrations of total copper in sediments of 17 sites sampled in Wellington Harbour in 2006, based on the <500 µm fraction of a single composite sample from each site

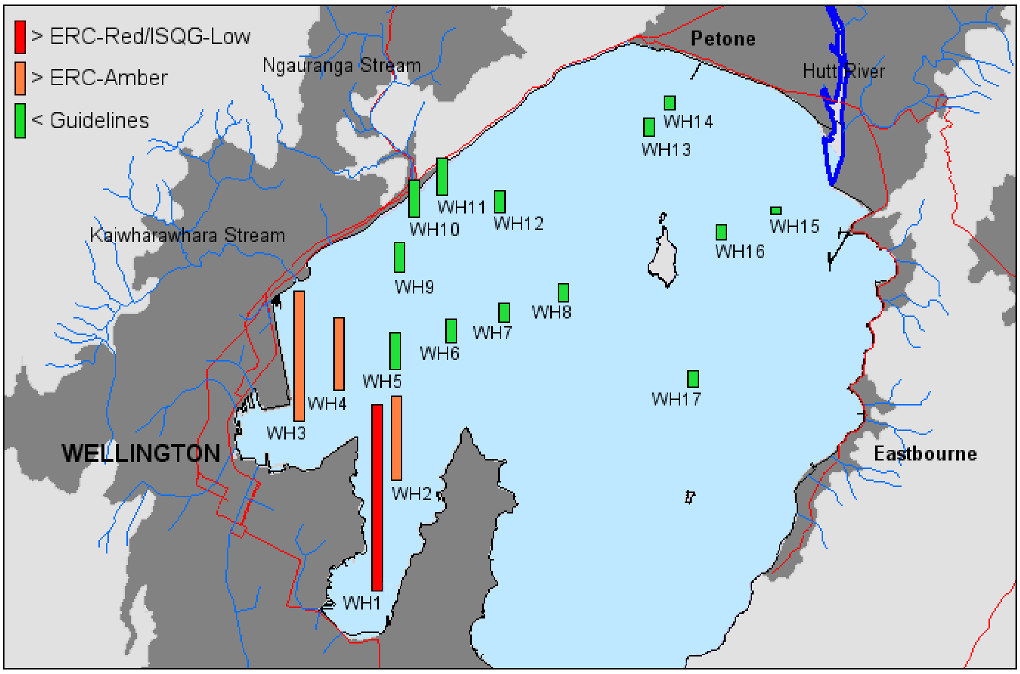


Figure 4.4: Mean concentrations of Total High Molecular Weight PAHs in sediments of 17 sites sampled in Wellington Harbour in 2006, based on the <500 µm fraction of five composite samples from each site

Of the 22 organochlorine pesticides analysed, only the insecticide DDT and its derivatives were consistently detected. Total DDT is present above sediment quality guidelines over much of the harbour (Figures 4.5 and 4.6), indicating that although its use in agriculture effectively ceased in the 1970s, and its use in urban areas was banned in the late 1980s, substantial sources remain in the environment.

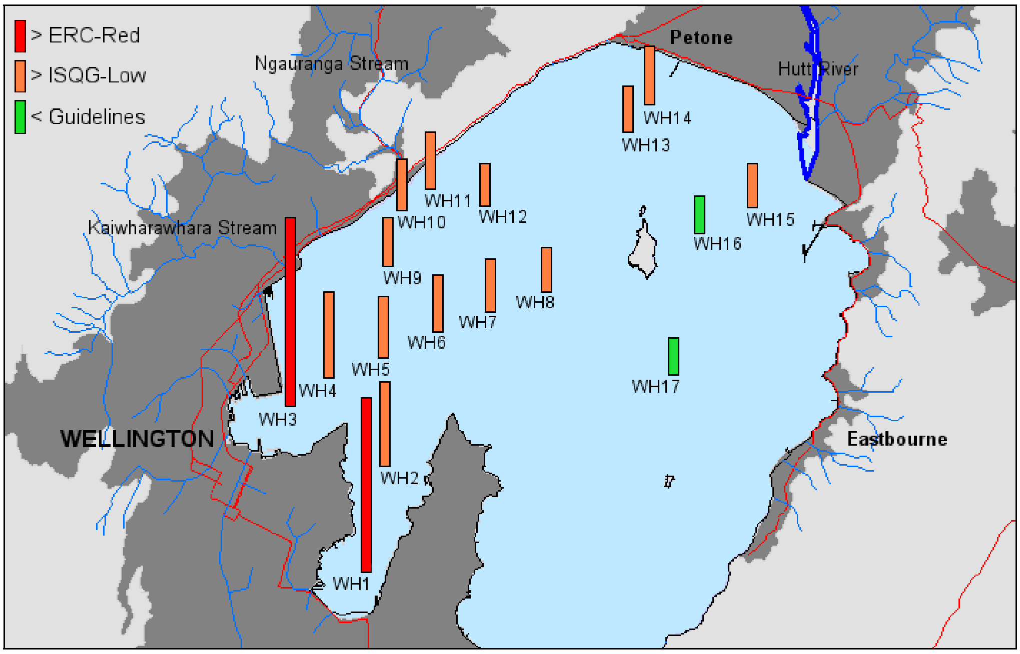


Figure 4.5: Mean concentrations of Total DDT in sediments of 17 sites sampled in Wellington Harbour in 2006, based on the <500 µm fraction of five composite samples from each site.

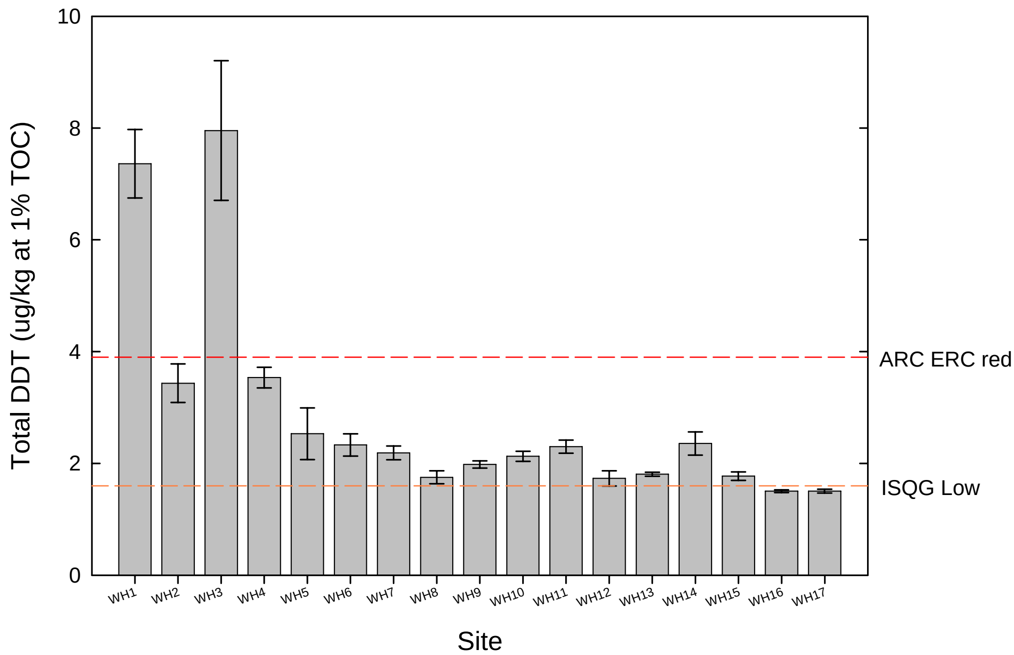


Figure 4.6: Mean concentrations of TOC-normalised[4] Total DDT in sediments of 17 sites sampled in Wellington Harbour in 2006, based on the <500 µm fraction of five composite samples from each site. The concentrations include “less than detection limit” values as a value one half of the detection limit. Error bars are ± 1 standard error of mean.

[4] The ANZECC and ERC sediment quality guidelines require organochlorine pesticide concentrations to be normalised to 1% total organic carbon content.

Recent studies of urban stormwater and streams in several subcatchments draining into Wellington Harbour (e.g., Milne & Watts 2008, Kingett Mitchell 2005), confirm that inputs of heavy metals, PAHs and DDT to the harbour are on-going. On-going organotin inputs are unlikely given that the use of butyltins as an antifoulant on small boats was banned in 1989 and is being phased out on large overseas commercial vessels.

4.3.2 Benthic ecology

A total of 101 species were found in the benthic fauna samples collected in November 2006 (Figure 4.7), predominantly polychaete worms, crustaceans, bivalve molluscs and nemertean worms. The fauna present at the investigation sites can be considered as being variants of an inner harbour subtidal fine sediment community occurring in water depths >10 m. The principal species in this community were Sipunculida sp.#1, Tanaidacea sp.#1, *Theora lubrica*, *Labiosthenolepis laevis*, *Cossura consimilis*, Paraonidae sp.#1, Phoxocephalidae sp.#1, Cirratulidae sp.#1, *Arthritica* sp.#1, *Maldane theodori*, *Aglaophamus macroura* and *Amphiura rosea*. The heart urchin *Echinocardium cordatum*, the bivalve *Dosina zelandica*, the rag-worm *Onuphis aucklandensis*, the bamboo worm *Asychis trifilosa*, or a combination of these species, most often dominated the biomass.

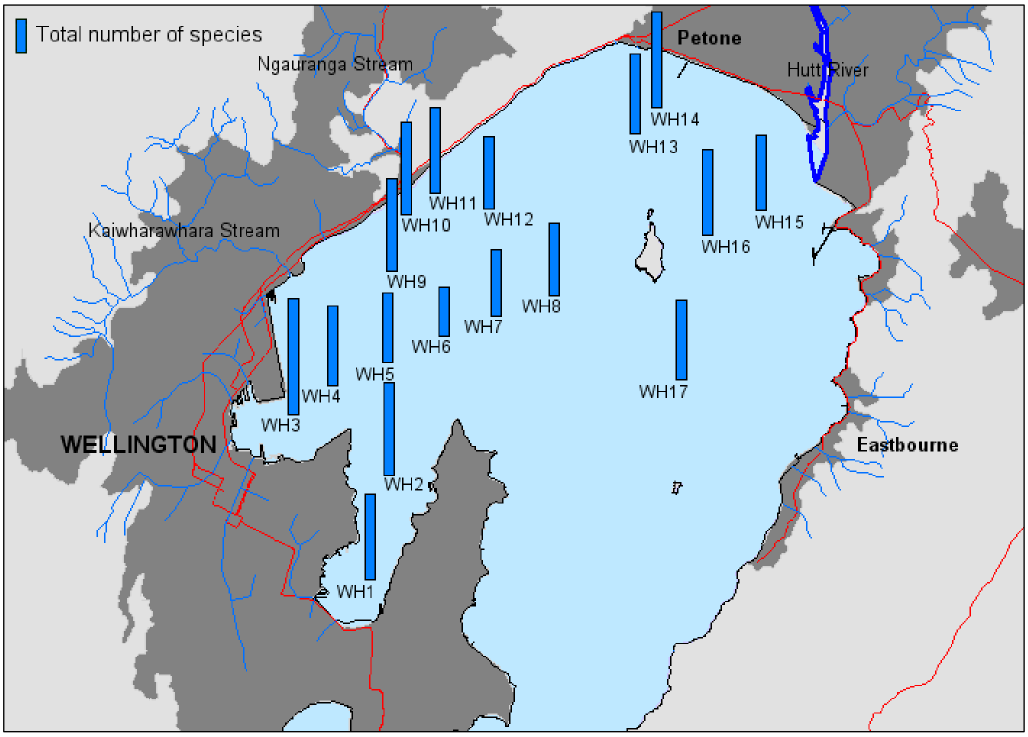


Figure 4.7: Number of species at each of the 17 sites sampled in Wellington Harbour in November 2006. Note that the scale used for the bars is unique to this map.

4.3.3 Relationship between the benthic community and chemical variables

Multi-variate statistical analyses show that variation in benthic community structure (i.e., species composition and abundance) across the 17 sites is not strongly correlated with the concentrations of the chemical contaminants that exceed sediment quality guidelines. Therefore, there is no clear evidence of significant adverse effects on the benthic fauna at the *community level* of organisation. However, this may not be the case at some sites (e.g., WH1 and WH3) in the future if contaminants continue to accumulate. This may also not be the case closer to shore. The number of far-field sites at which sediment quality guidelines were exceeded in this investigation, and the offshore gradients exhibited by the contaminants involved, clearly indicates that concentrations of these contaminants will be higher as their onshore sources are approached, with a parallel increase in the likelihood of effects on the benthic ecology.

4.4 Future monitoring

Five-yearly monitoring of a subset of the 17 investigation sites (WH1–WH5, WH9, WH11, WH13, WH15, and possibly a new site of eastern Petone) is recommended in order to monitor trends in contamination concentrations and any changes in benthic community structure.

4.5 Synthesis

The marine sediments in Wellington Harbour have been contaminated with toxic compounds derived from the surrounding catchments. Some of these compounds, including several metals, PAHs and Total DDT, are present at concentrations above sediment quality guidelines.

The strong offshore gradients in contaminant concentrations and the chemical nature of some of the contaminants in the sediments of Wellington Harbour provide a clear indication of their land-based origin. A review of the available stormwater quality and stream monitoring data from the harbour’s catchment indicates that urban stormwater is the principal agent in the transport of the majority of these contaminants to the harbour seabed, either directly or by way of urban streams. While the stormwater discharges continue in their present form it is highly likely that the level of contaminants in the harbour sediments will increase.

An examination of the benthic fauna present at each site did not provide any clear evidence of the elevated contaminants measured in the sediments having resulted in significant adverse effects on benthic community structure as at November 2006. While the absence of obvious effects at this level is encouraging, the thresholds for such effects are still not known for this environment, indicating periodic reassessments of both sediment quality and benthic ecology will be needed.

5. Lake Onoke risk assessment and monitoring

5.1 Introduction and background

Lake Onoke (630ha, Figure 5.1) is a highly modified shallow coastal lake/estuary fed by the lower Ruamahanga River. The lake drains to the sea at Palliser Bay through an opening at the southeastern end of the lake. The lake outlet regularly blocks and is opened artificially. In September 2007, Greater Wellington engaged Wriggle Coastal Management to undertake a synoptic field survey and ecological vulnerability assessment of Lake Onoke, in order to determine monitoring needs and priorities. This work, summarised here from a report by Robertson & Stevens (2007a), followed an earlier assessment of Wairarapa coastal habitats which identified Lake Onoke as having a high risk of nutrient, sedimentation, pathogen and habitat loss problems, and a lack of ecological information for the lake (Robertson & Stevens 2007b).

Figure 5.1: Lake Onoke from Lake Ferry

5.2 Vulnerability assessment

The Ecological Vulnerability Assessment undertaken followed an adaptation of UNESCO (2000) methodology. The aim of the assessment is to represent how an estuary ecosystem is likely to react to the effects of stressors – the causes of common estuary issues such as excessive sedimentation, nutrient enrichment and habitat loss – so that an overall "vulnerability" rating can be determined, and priority monitoring indicators can be identified.

The Ecological Vulnerability Assessment rated Lake Onoke's existing condition as poor for sedimentation, nutrients, saltmarsh and aquatic macrophytes. This poor rating reflects significant modifications to the lake environment including the loss of a large proportion of saltmarsh habitat, likely loss of submerged aquatic macrophyte beds, and reduced water and sediment quality. Most of these modifications can be attributed to the extensive drainage, river training and realignment, reclamation and artificial lake outlet actions which were undertaken to develop pastureland and minimise flooding, and to past and present catchment landuse intensification.

Despite these modifications, the lake still has considerable human uses and values, particularly fishing, boating and natural character. Ecologically it is valued for its remaining saltmarsh habitat (particularly Pounui Lagoon which drains into the northwestern end of the lake), adjoining duneland on Onoke Spit, and its bird and fish-life (Wellington Regional Council 2008). The major threats or stressors to these existing values were identified as:

- high nutrient, sediment and pathogen inputs from terrestrial catchment intensification and altered weather patterns from climate change;
- inappropriate timing and level control of artificial lake mouth opening;
- further drainage and reclamation of saltmarsh habitat;
- stock grazing in saltmarsh habitat;
- vehicle damage to Onoke Spit dune vegetation and birdlife;
- ongoing loss of connectivity between Lake Onoke and Pounui Lagoon; and
- further loss of margin buffer land through development.

Because its outlet has a tendency to block, Lake Onoke has a high natural susceptibility to issues such as eutrophication (excessive nutrients), sedimentation, disease risk (pathogens) and habitat loss. However, the ability to manually open the mouth and maintain tidal flushing means the susceptibility to further change is rated as moderate. Therefore, although the existing lake condition is rated poor, the overall ecological vulnerability rating for the lake is "moderate".

5.3 Monitoring recommendations

Robertson & Stevens (2007a) recommended establishing a "baseline" of existing conditions, with subsequent monitoring being generally repeated on a five-yearly cycle or as determined otherwise by the monitoring results. The ongoing monitoring will measure future changes that may result in impacts on existing values and provide additional information to aid management and monitoring decisions.

Baseline monitoring would target the significant issues of eutrophication, sedimentation, disease risk and habitat loss by including such things as:

- testing of lake-bed sediments for grain size, nitrogen, phosphorus and organic carbon;
- assessment of lake-bed sedimentation rates;
- water clarity, light penetration and chlorophyll-*a* measurements over spring to autumn;
- broad-scale mapping of wetland and terrestrial margin vegetation of Lake Onoke and Pounui Lagoon, and percent cover of macroalgae and submerged macrophytes in Pounui Lagoon (if present); and

- re-establishment of monitoring of indicator bacteria (disease risk assessment) at a representative site used for recreation.

The following investigations were also suggested by Robertson & Stevens (2007a) as possible options for improving the ecological quality of Lake Onoke:

- assessing the pros and cons of improving the connectivity between Lake Onoke and Pounui Lagoon; and
- investigating whether changes to lake level management and mouth opening could improve lake ecology.

5.4 Next steps

Implementation of the monitoring recommendations listed in Section 5.3 is currently being considered, alongside other coastal monitoring priorities in the Wellington region (e.g., annual intertidal monitoring of macroalgal cover and sedimentation rates in Porirua Harbour).

6. Broad-scale habitat mapping and fine-scale ecological monitoring of Porirua Harbour

6.1 Introduction and background

In April 2007, Greater Wellington and Porirua City Council engaged Wriggle Coastal Management to prepare a brief overview of the key issues and risks to the health of the Porirua Harbour estuary system, including areas where further investigations, monitoring or research may be required. This review (Robertson & Stevens 2007c) recommended a range of monitoring incorporating:

- broad-scale mapping of the existing substrate and vegetation types, including eel grass and salt marsh beds as well as macroalgal density;
- deployment of sedimentation plates to measure sedimentation rates on an annual basis; and
- fine-scale intertidal monitoring of selected sediment condition indicators, including heavy metals, organic matter, sediment grain size and macroinvertebrate abundance and diversity.

This monitoring was undertaken by Wriggle Coastal Management over the 2007/08 summer and is summarised here. Full details of the monitoring are reported in Robertson & Stevens (2008a) and Stevens & Robertson (2008). The broad-scale habitat mapping and fine-scale ecological monitoring were jointly funded by Porirua City Council and complement earlier investigations of sediment quality in the subtidal areas of the Porirua Harbour (Williamson et al. 2005, Stephenson & Mills 2006).

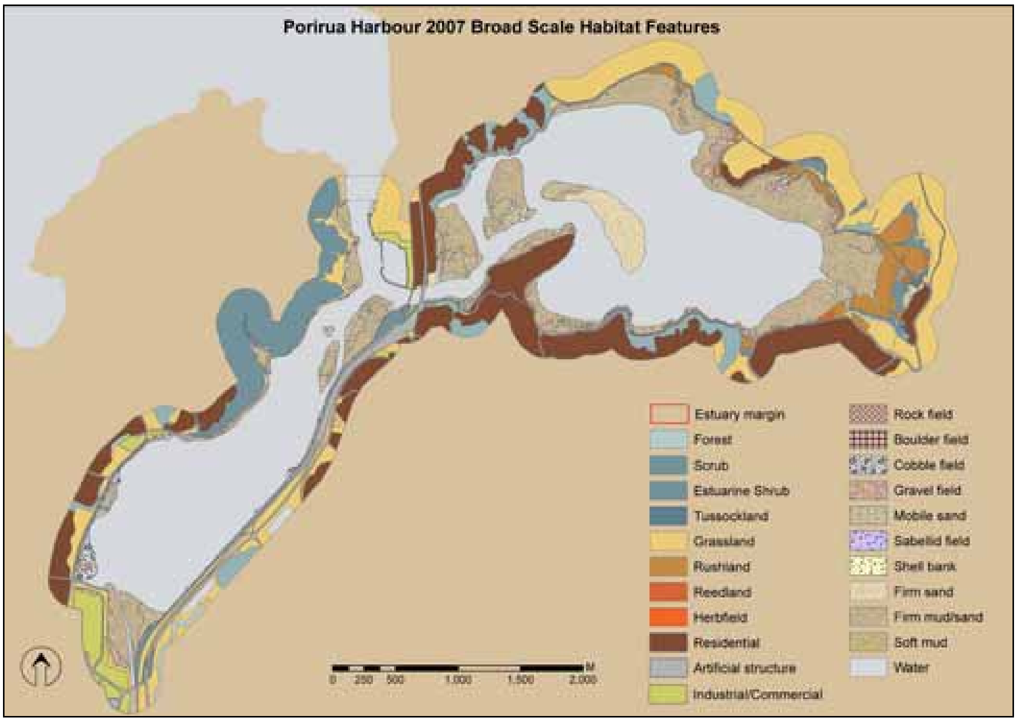
6.2 Broad-scale habitat mapping

The broad-scale survey assessed the types of substrate (e.g., firm sand, soft sand, mud, gravel) and vegetation (e.g., macroalgal beds, seagrass beds, saltmarsh vegetation, exotic weeds) present throughout the intertidal areas of the Porirua Harbour. The survey was undertaken in December 2007, with habitat cover recorded onto laminated aerial photographs and subsequently digitised and entered into a GIS framework.

6.2.1 Key findings

The intertidal mapping (Figure 6.1) of Porirua Harbour showed:

- The majority of the intertidal area of both arms was dominated by unvegetated, firm muddy sands (122 ha in the Pauatahanui Arm and 33 ha in the Onepoto (Porirua) Arm). Soft muds occupied only 1.9 ha and 1.5 ha respectively.
- Saltmarsh vegetation was virtually non-existent in the Onepoto Arm but occupied 51 ha in the Pauatahanui Arm where it was dominated by wide beds of rushland. As the terrestrial influence increased, rushland transitioned through areas dominated by saltmarsh ribbonwood *(Plagianthus divaricatus)* and grassland.



(Source: Stevens & Robertson (2008)

Figure 6.1: Summary of the broad-scale habitat (substrate and vegetation) features of Porirua Harbour, December 2007

- Areas of seagrass *(Zostera)* were relatively extensive, 41.2 ha in the Pauatahanui Arm and 17.3 ha in the Onepoto Arm. The beds appeared healthy, stable and relatively free of fine sediment.
- Both arms of the harbour have a poor terrestrial vegetation buffer, reflecting the predominance of residential areas, grassland and artificial structures (primarily road and rail).

The broad-scale results, together with other catchment and harbour information, were used to provide an understanding of the condition of the harbour in terms of some common estuary issues; sedimentation, eutrophication and habitat loss. From this assessment it was concluded that:

- The sedimentation risk is rated moderate for the whole harbour. Ongoing management and monitoring will be required; excessive sediment inputs in an estuary lead to infilling with muds, reducing biodiversity and human values and uses.
- The whole harbour is moderately eutrophic (enriched), indicating a risk of nuisance macroalgal growth (e.g., sea lettuce). This was evident in the broad-scale macroalgal mapping results; approximately 70% of the intertidal area of each arm had macroalgal cover of at least 5%. Continued surveys of macroalgal cover are recommended.
- Habitat loss is rated as moderate in the Pauatahanui Arm and very high in the Onepoto Arm. The very high rating for the Onepoto Arm reflects the extensive modification this arm has undergone in response to urban development. Loss of habitat is an important issue; estuaries function best with a large area of rooted vegetation (i.e., saltmarsh and seagrass) as well

as a healthy vegetated terrestrial margin. Loss of this habitat reduces wildlife, recreational and aesthetic values, and also adversely impacts on an estuary's role in flood and erosion protection, contaminant mitigation, sediment stability and nutrient cycling. Although habitat loss in the Onepoto Arm is significant, there is large scope for restoration of saltmarsh and margin vegetation.

6.3 Fine-scale ecological monitoring

Fine-scale monitoring was undertaken at two intertidal sites within each arm of the Porirua Harbour in January 2008 (Figure 6.2 & Table A2.2, Appendix 2). This monitoring included assessments of 10 plots for sediment grain size, oxygenation (Figure 6.3), nutrient and organic content, contamination, and benthic (sediment-dwelling) flora and fauna. The methods used were based on an extension of the tools included in the National Estuary Monitoring Protocol (Robertson et al. 2002). One extension of the protocol was the installation of 15 sedimentation plates at selected intertidal and subtidal locations to enable long-term monitoring of sedimentation rates (Figures 6.2 & 6.4).

(Source: Robertson & Stevens (2008a)

Figure 6.2: Location of fine-scale monitoring sites (with sampling plot layout) and sedimentation plates in Porirua Harbour

(Source: Robertson & Stevens (2008a)

Figure 6.3: Measuring the depth of oxygenated sediment in a core sample from the Onepoto Arm of Porirua Habour. The greater the depth of oxygenated sediment (indicated by the lighter-coloured surface layer), the better the conditions for the associated benthic flora and fauna.

Figure 6.4: Installing a sedimentation plate in the Pauatahanui Arm of the Porirua Harbour. The depth to each sediment plate will be measured each year, allowing the sedimentation rate to be determined.

6.3.1 Key findings

The key findings of the fine-scale assessment showed:

- Low to moderate concentrations of organic matter and nutrients in the sediments, with the highest concentrations recorded at the muddier sites (Por A and Pau A). Catchment nutrient load management is recommended to help maintain existing sediment nutrient levels; this is important because elevated sediment nutrient levels may result in a shift to sediment anoxia (low oxygen), leading to increased availability of nutrients (and other contaminants) and nuisance algal growth. Sediment anoxia can also result in adverse effects on benthic fauna. Although the sediments are predominantly sand (77-99% sand) and are moderately oxygenated at the present time, there were localised areas in the upper Onepoto Arm where the sediments are already anoxic.

- A benthic community dominated (in terms of abundance) by polychaete worms (>50%), bivalve molluscs, crustaceans and gastropod molluscs. Overall, the benthic community was rated "unbalanced", with elevated numbers of organisms that tolerate moderate levels of mud and organic enrichment (e.g., the polychaete *Heteromastus filiformis*).

- Total recoverable heavy metal concentrations in the sediments (measured as an indicator of potential toxicants) well within ANZECC (2000) Interim Sediment Quality Guidelines, but a localised risk of sediment contamination from toxicants in urban stormwater in intertidal sediments at the southern end (site Por B) of the Onepoto Arm (this site recorded the highest metal concentrations). It is important to minimise sediment contamination; if inputs of toxicants are excessive, biodiversity may be threatened and shellfish may be unsuitable for consumption.

The fine-scale results, together with other catchment and monitoring information, supported the findings of the broad-scale assessment; the harbour has a moderate sedimentation rating and is moderately enriched. Although heavy metal concentrations were relatively low at the intertidal monitoring sites, previous investigations by Greater Wellington (e.g., Williamson et al. 2005, Stephenson & Mills 2006) have found significantly higher concentrations in the subtidal basins, particularly in the Onepoto Arm. This is not surprising as metals tend to be bound to the mud fraction of sediments and the subtidal basins are dominated by fine muds.

6.4 Summary

The broad-scale habitat mapping and fine-scale ecological monitoring have provided a valuable assessment of the health of the Porirua Harbour. Overall, the harbour is considered moderately eutrophic with a moderate sedimentation risk; the installation of sediment measurement plates at selected intertidal and subtidal locations will enable this risk to be quantified. Loss of habitat has also been identified as an issue, particularly in the Onepoto Arm which has minimal saltmarsh vegetation. The southern end of the Onepoto Arm also has the highest sediment heavy metal concentrations, reflecting greater contaminant inputs from urban stormwater.

6.5 Future monitoring

Porirua Harbour has been identified as a high priority for ongoing monitoring. At this stage regular (annual) assessments of sedimentation rates and nuisance macroalgal cover are recommended, together with a further two to three years of annual fine-scale intertidal monitoring to provide a sound baseline against which future changes in the health of the harbour can be assessed. Continued monitoring of contaminants in the subtidal sediments is also proposed, with the next assessment to be undertaken in late 2008.

7. Whareama Estuary fine-scale ecological monitoring

7.1 Introduction and background

In January 2008, Wriggle Coastal Management undertook a fine-scale ecological assessment of Whareama Estuary, a 12 km long, tidal river lagoon estuary located on Wairarapa's eastern coast. This work, summarised here from a report by Robertson & Stevens (2008b), followed an earlier assessment of Wairarapa coastal habitats (Robertson & Stevens 2007b) which recommended a long-term monitoring programme for the Wairarapa coast. Included in the programme was monitoring of the long-term condition (benthic fauna and sediment quality) of the Whareama Estuary.

7.2 Monitoring sites and methods

Monitoring was undertaken at two sites located on the unvegetated intertidal mudflats (Figure 7.1 & Table A2.3, Appendix 2). Ten plots were sampled at each site, with assessments made of sediment grain size, oxygenation, nutrient and organic content, contamination (heavy metals and pesticides), and benthic (sediment-dwelling) flora and fauna. The fine-scale monitoring methods were based on an extension of the tools included in the National Estuary Monitoring Protocol (Robertson et al. 2002). One extension of the protocol was the installation of four sedimentation plates in muddy habitat in the lower estuary to enable long-term monitoring of sedimentation rates.

(Source: Robertson & Stevens (2008b)

Figure 7.1: Whareama Estuary intertidal mudflats

7.3 Key findings

The results for the selected physical, chemical and biological indicators of estuary condition showed that the dominant intertidal habitat was generally in “fair” to “good” condition. Nitrogen, phosphorus and organic carbon concentrations were classed as low to moderate. Heavy metal concentrations were very low to low and pesticide concentrations were below laboratory detection limits. Of concern was the very muddy and poorly oxygenated nature of the sediments (70% mud) which create poor conditions for plants and animals. As a consequence of this (and possibly periodic exposure to low salinity), the condition of the biological community was classified as “slightly to moderately polluted”; the community was largely dominated by small subsurface deposit-feeding organisms that prefer moderate mud and organic enrichment levels (e.g., the bivalve *Arthritica* sp. and polychaetes *Heteromastus filiformis* and *Scolecolepides benhami*).

Catchment sediment runoff management is important, particularly given the muddy nature of the Whareama estuary, the natural soft-rock type (mudstone) and the very erosion-prone nature of the catchment. If organic enrichment and the mud content in the estuary increase, sediment anoxia could get worse and result in sediment nutrients becoming more available to stimulate nuisance algal growth.

7.4 Future monitoring

The 2008 fine-scale ecological assessment is the first in a series of three annual assessments proposed to establish a “baseline” of existing conditions in the Whareama Estuary. After the three-year baseline is complete, monitoring is likely to reduce to five-yearly intervals or as determined otherwise by the monitoring results.

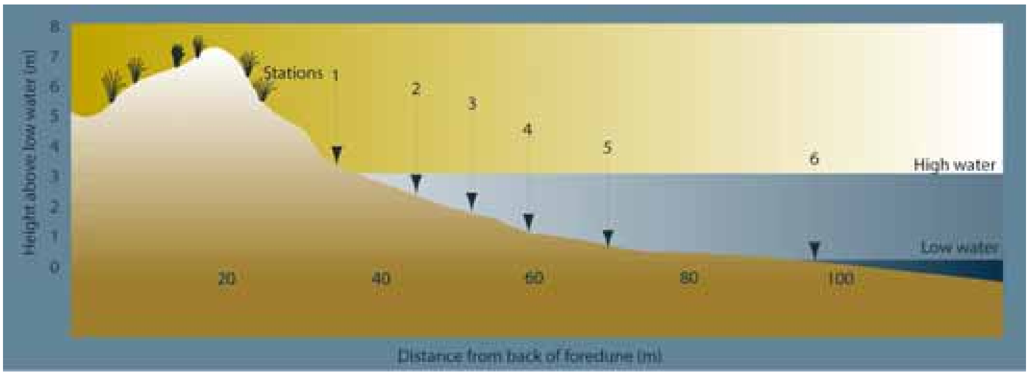
8. Castlepoint Beach fine-scale monitoring

8.1 Introduction and background

In January 2008, Wriggle Coastal Management undertook a fine-scale ecological assessment of Castlepoint Beach, a 4.5 km long exposed beach located on the Wairarapa's northeastern coast. This work, summarised here from a report by Robertson & Stevens (2008c), followed an earlier assessment of Wairarapa coastal habitats (Robertson & Stevens 2007b) which recommended a long-term monitoring programme for the Wairarapa coast. Included in the programme was the establishment of one long-term monitoring site for dissipative[5] beach types between Castlepoint and the Whakataki River.

8.2 Monitoring sites and methods

Monitoring was undertaken at two intertidal sites located towards the northern end of the beach, approximately 750 m south of the Whakataki Estuary (Table A2.4, Appendix 2). Six stations were sampled along two transects 50 m apart (Figure 8.1), with assessments made of sediment grain size, sediment oxygenation and benthic (sediment-dwelling) fauna. Assessments of sediment nutrient and contaminant concentrations were not undertaken; there are no major nutrient inputs on semi-exposed beaches like Castlepoint, and the risk of toxic contamination is very low.



(Source: Robertson & Stevens (2008c)

Figure 8.1: Cross-section of sampling transect at Castlepoint Beach

8.3 Key findings

The results for the selected physical and biological indicators of beach condition showed that the dominant intertidal habitat was generally in good condition. The beach sediments consisted of well-oxygenated sands, with a typical exposed beach benthic invertebrate community dominated by crustaceans (mainly isopods, with smaller numbers of amphipods) and beetles. Such conditions indicate an oligotrophic (nutrient-poor) situation, which is typical of exposed New Zealand beaches.

[5] Castlepoint Beach is classified as dissipative-intermediate beach, meaning that is relatively flat, and fronted by a moderately wide surf zone in which waves dissipate much of their energy.

The need for management of dunes in the area was also noted; introduced marram grass, the main sand-binding species on the beach, has inferior sand-binding and erosion control capabilities to the native sand-binding species (i.e., pingao and spinifex).

8.4 Future monitoring

The 2008 fine-scale ecological assessment is the first in a series of three annual assessments proposed to establish a "baseline" of existing conditions at Castlepoint Beach. After the three-year baseline is complete, monitoring is likely to reduce to five-yearly intervals or as determined otherwise by the monitoring results.

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Acknowledgements

Alice Ryan compiled the microbiological summary statistics.

Appendix 1: Microbiological water quality monitoring sites

Area	Site Name	NZ Map Grid		Type
		Easting	Northing	
Hutt	Petone Beach @ Water Ski Club	2665765	5996304	Marine
Hutt	Petone Beach @ Sydney Street	2667067	5995961	Marine
Hutt	Petone Beach @ Settlers Museum	2667577	5995770	Marine
Hutt	Petone Beach @ Kiosk	2668348	5995425	Marine
Hutt	Sorrento Bay	2669654	5993098	Marine*
Hutt	Lowry Bay @ Cheviot Road	2670228	5992605	Marine
Hutt	York Bay	2669999	5991874	Marine
Hutt	Days Bay @ Wellesley College	2669639	5990243	Marine
Hutt	Days Bay @ Wharf	2669677	5990027	Marine
Hutt	Days Bay @ Moana Road	2669605	5989834	Marine
Hutt	Rona Bay @ N end of Cliff Bishop Park	2669132	5989367	Marine
Hutt	Rona Bay @ Wharf	2668753	5989084	Marine
Hutt	Robinson Bay @ HW Shortt Rec Ground	2668542	5988387	Marine
Hutt	Robinson Bay @ Nikau Street	2668154	5987569	Marine
Hutt	Camp Bay	2667013	5986001	Marine
Kapiti	Otaki Beach @ Surf Club	2688639	6050044	Marine*
Kapiti	Otaki Beach @ Rangiuru Road	2688028	6048783	Marine
Kapiti	Te Horo Beach S of Mangaone Stream	2685797	6044192	Marine
Kapiti	Te Horo Beach @ Kitchener Street	2685513	6043648	Marine
Kapiti	Peka Peka Beach @ Road End	2683233	6039620	Marine*
Kapiti	Waikanae Beach @ William Street	2681406	6037299	Marine
Kapiti	Waikanae Beach @ Tutere St Tennis Courts	2680673	6036577	Marine
Kapiti	Waikanae Beach @ Ara Kuaka Carpark	2679532	6035693	Marine
Kapiti	Paraparaumu Beach @ Ngapotiki Street	2677561	6034477	Marine
Kapiti	Paraparaumu Beach @ Nathan Avenue	2677051	6033889	Marine
Kapiti	Paraparaumu Beach @ Maclean Park	2676712	6032982	Marine
Kapiti	Paraparaumu Beach @ Toru Road	2676595	6032430	Marine
Kapiti	Paraparaumu Beach @ Wharemauku Road	2676521	6031785	Marine
Kapiti	Raumati Beach @ Tainui Street	2676549	6030944	Marine
Kapiti	Raumati Beach @ Marine Gardens	2676535	6030156	Marine
Kapiti	Raumati Beach @ Aotea Road	2676433	6029244	Marine
Kapiti	Raumati Beach @ Hydes Road	2676337	6028550	Marine*
Kapiti	Paekakariki Beach @ Whareroa Road	2675617	6025843	Marine
Kapiti	Paekakariki Beach @ Surf Club	2674810	6023988	Marine
Kapiti	Paekakariki Beach @ Memorial Hall	2674452	6023305	Marine
Porirua	Pukerua Bay	2669309	6017968	Marine
Porirua	Karehana Bay @ Cluny Road	2666113	6013074	Marine
Porirua	Plimmerton Beach @ Bath Street	2666726	6012030	Marine
Porirua	Plimmerton Beach @ Queens Avenue	2666790	6011888	Marine
Porirua	South Beach @ Plimmerton	2666830	6011588	Marine
Porirua	Paremata Beach @ Pascoe Avenue	2667137	6010447	Marine
Porirua	Pauatahanui Inlet @ Water Ski Club	2668094	6011307	Marine
Porirua	Pauatahanui Inlet @ Motukaraka Point	2669506	6011052	Marine*
Porirua	Pauatahanui Inlet @ Paremata Bridge	2667173	6009998	Marine
Porirua	Pauatahanui Inlet @ Browns Bay	2668059	6009547	Marine*
Porirua	Porirua Harbour @ Rowing Club	2664911	6008661	Marine*
Porirua	Titahi Bay @ Bay Drive	2664152	6009883	Marine
Porirua	Titahi Bay at Toms Road	2664130	6009571	Marine
Porirua	Titahi Bay @ South Beach Access Road	2663926	6009396	Marine
Porirua	Onehunga Bay	2665816	6010895	Marine

Area	Site Name	NZ Map Grid		Type
		Easting	Northing	
Wairarapa	Castlepoint Beach @ Castlepoint Stream	2781366	6029287	Marine
Wairarapa	Castlepoint Beach @ Smelly Creek	2781670	6028931	Marine
Wairarapa	Riversdale Beach @ Lagoon Mouth	2768974	6009275	Marine
Wairarapa	Riversdale Beach Between the Flags	2768445	6008680	Marine
Wairarapa	Riversdale Beach South	2767844	6007246	Marine
Wellington	Aotea Lagoon	2659007	5989395	Marine
Wellington	Oriental Bay @ Freyberg Beach	2659942	5989176	Marine
Wellington	Oriental Bay @ Wishing Well	2660140	5989098	Marine
Wellington	Oriental Bay @ Band Rotunda	2660265	5989087	Marine
Wellington	Balaena Bay	2660980	5988979	Marine
Wellington	Kio Bay	2661163	5988311	Marine
Wellington	Hataitai Beach	2660654	5987442	Marine
Wellington	Shark Bay	2662233	5987909	Marine*
Wellington	Mahanga Bay	2663490	5988828	Marine*
Wellington	Scorching Bay	2663539	5988360	Marine
Wellington	Worser Bay	2663097	5986535	Marine
Wellington	Seatoun Beach @ Wharf	2663152	5985946	Marine
Wellington	Seatoun Beach @ Inglis Street	2663428	5985706	Marine
Wellington	Breaker Bay	2663335	5984682	Marine
Wellington	Lyall Bay @ Tirangi Road	2660770	5984942	Marine
Wellington	Lyall Bay @ Onepu Road	2660309	5984828	Marine
Wellington	Lyall Bay @ Queens Drive	2660013	5984580	Marine
Wellington	Princess Bay	2659609	5983216	Marine
Wellington	Island Bay @ Surf Club	2658400	5983302	Marine
Wellington	Island Bay @ Reef St Recreation Ground	2658252	5983254	Marine
Wellington	Island Bay @ Derwent Street	2658178	5983127	Marine
Wellington	Owhiro Bay	2657145	5983174	Marine

* Water quality is also monitored for recreational shellfish gathering purposes

Appendix 2: Sediment and benthic ecology sampling sites

Table A2.1: Site position and collection details for the Wellington Harbour marine sediment quality investigation (Oct/Nov 2006)

Site	Location	Date	NZ Map Grid		Depth
			Easting	Northing	(m)
WH1 WH1B	Southern Evans Bay	11/10/06 13/11/06	2661552	5987060	19
WH2 WH2B	Northern Evans Bay	11/10/06 13/11/06	2661732	5989000	19
WH3 WH3B	Lambton Basin entrance	03/11/06 17/11/06	2660078	5990052	18
WH4 WH4B	≈ 0.7 km NW of Point Jerningham	03/11/06 17/11/06	2660785	5990501	20
WH5 WH5B	≈ 1.2 km NNE of Point Jerningham	18/10/06 17/11/06	2661770	5990851	21
WH6 WH6B	≈ 1.25 km NW of Point Halswell	18/10/06 17/11/06	2662687	5991294	22
WH7 WH7B	≈ 1.5 km N of Point Halswell	18/10/06 17/11/06	2663603	5991645	22
WH8 WH8B	≈ 1.5 km SW of Matiu/Somes Island	18/10/06 13/11/06	2664588	5991995	23
WH9 WH9B	≈ 1.5 km SSE of Ngauranga Stream mouth	03/11/06 08/11/06	2661943	5992421	20
WH10 WH10B	≈ 0.5 km SSE of Ngauranga Stream mouth	11/10/06 08/11/06	2662034	5993437	20
WH11 WH11B	≈ 0.5 km E of Ngauranga Stream mouth	03/11/06 08/11/06	2662530	5993797	20
WH12 WH12B	≈ 1.5km E of Ngauranga Stream mouth	03/11/06 08/11/06	2663502	5993499	21
WH13 WH13B	≈ 1.25 km S of Petone Wharf	11/10/06 08/11/06	2666045	5994834	16
WH14 WH14B	≈ 0.65 km S of Petone Wharf	11/10/06 08/11/06	2666404	5995289	12
WH15 WH15B	≈ 1.1 km SW of Seaview (Hutt River mouth)	11/10/06 13/11/06	2668182	5993492	16
WH16 WH16B	≈ 2.1 km SW of Seaview (Hutt River mouth)	18/10/06 13/11/06	2667265	5993049	19
WH17 WH17B	≈ 1.6 km NNW of Makaro/Ward Island	18/10/06 13/11/06	2666792	5990560	21

B = Benthic ecology collection area

Table A2.2: Porirua Harbour intertidal sampling locations (Jan 2008)

Sampling Station	NZ Map Grid	
	Easting	Northing
Porirua A	2666477 (Plot 01) 2666515 (Plot 10)	6009488 (Plot 01) 6009525 (Plot 10)
Porirua B	2770091 (Plot 01) 2770074 (Plot 10)	6017048 (Plot 01) 6017024 (Plot 10)
Pauatahanui A	2667263 (Plot 01) 2667266 (Plot 10)	6010358 (Plot 01) 6010315 (Plot 10)
Pauatahanui B	2670378 (Plot 01) 2670398 (Plot 10)	6010057 (Plot 01) 6010055 (Plot 10)

Table A2.3: Whareama Estuary intertidal sampling locations (Jan 2008)

Sampling Station	NZ Map Grid	
	Easting	Northing
Whareama A	2770710 (Plot 01) 2770691 (Plot 10)	6017073 (Plot 01) 6017068 (Plot 10)
Whareama B	2770091 (Plot 01) 2770074 (Plot 10)	6017048 (Plot 01) 6017024 (Plot 10)

Table A2.4: Castlepoint Beach sampling locations (Jan 2008)

Sampling Station	NZ Map Grid	
	Easting	Northing
Castlepoint A	2781628 (Plot 01) 2781679 (Plot 06)	6031520 (Plot 01) 6031502 (Plot 06)
Castlepoint B	2781609 (Plot 01) 2781664 (Plot 06)	6031467 (Plot 01) 6031458 (Plot 06)